

HEART MURMURS

PART II

BY

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A phonocardiographic study of the innocent heart murmurs and those found in mitral stenosis was described in an earlier publication (*Brit. Heart J.*, 1947, 9, 1). In this paper the murmurs appearing in aortic valvular disease, hypertension, congenital heart disease, heart block, and in anæmia are examined.

III. THE MURMURS OF AORTIC VALVULAR DISEASE

The finding of a systolic murmur in the mitral area in patients with disease of the aortic valve is commonplace. Often it is difficult on clinical grounds to decide the source of the mitral murmur, whether it comes from the aortic valve, whether it is caused by the hypertrophied left ventricle, or whether it arises from associated disease of the mitral valve. Indeed, so loud is the mitral murmur in many patients with aortic valvular disease, especially stenosis, that it has seemed natural to assume that the mitral valve is also affected; cardioscopy has then been applied to decide whether mitral stenosis accompanied it or not, but often this examination has been inconclusive.

A phonocardiogram was recorded in 40 cases of aortic valvular disease from the mitral area for it was to the elucidation of the mitral systolic murmur that the investigation was primarily directed. Often a record was taken from the aortic area as well, but as it added no exceptional information, routine recording in this area was not pursued. Among the 40 cases there were 10 with aortic stenosis, 20 with aortic incompetence, and 10 with probably aortic valve sclerosis. The phonocardiographic findings in each group will be described in turn.

AORTIC STENOSIS

Not all the cases of aortic stenosis showed a thrill, but each had a loud and rough systolic murmur both in the aortic and mitral areas. The presence or absence of diastolic murmurs in both these areas was noted. The electrocardiogram was often abnormal; on cardioscopy a varying degree of left ventricular enlargement was found, and as a rule the aortic shadow was abnormal, commonly from unfolding of the aorta.

The mitral systolic murmur in the phonocardiogram started at the S line in five cases, immediately after the S line in three, and a little later in another (Fig. 21 and 22). In one case where the murmur started before the S line there was a mid-diastolic murmur as proof of the association of mitral stenosis. The systolic murmur always continued up to or within a short distance of the second heart sound.

In 2 of the 10 cases an early diastolic murmur of aortic incompetence was heard with the stethoscope although the systolic murmur was more in evidence. The remaining 8 were regarded as uncomplicated aortic stenosis because the murmur of incompetence had not been found although it had been sought diligently by direct auscultation during halted respiration

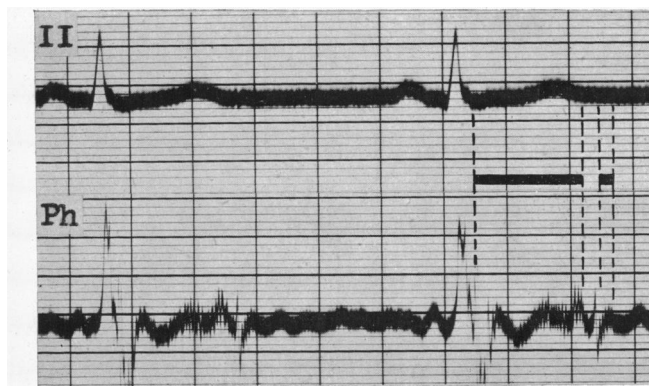


FIG. 21.—Aortic stenosis. The systolic murmur starts at the S line, and a diastolic murmur following the second heart sound is evidence of accompanying aortic incompetence.

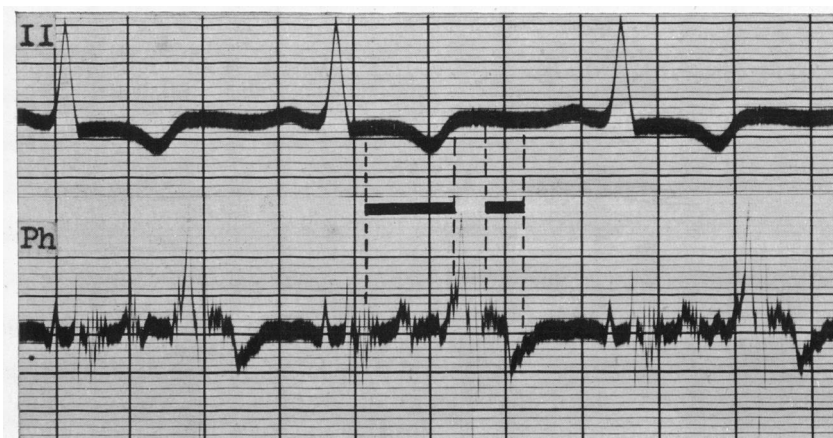


FIG. 22.—Aortic stenosis. The systolic murmur starts a little later than the S line. A diastolic murmur follows the second heart sound, giving proof of aortic incompetence, although this murmur was not heard on auscultation.

and with the patient in the upright posture; yet in all eight of them a murmur immediately following the second heart sound was recorded in the phonocardiogram proving the presence of aortic incompetence.

AORTIC INCOMPETENCE

There were 20 cases of aortic incompetence in which a rheumatic origin could not be substantiated on clinical grounds although the comparative youthfulness of five supported that ætiology. Radiological examination too could not establish definitely the presence of mitral disease; in the right oblique position the left auricular impression was usually prominent but it was difficult to tell with certainty whether this was caused by a displacement backwards of a normal left auricle due to the enlarged left ventricle, or caused by a left auricle distended from mitral disease.

In 8 cases the aortic incompetence was considered to be of syphilitic origin, but in 4 of these the phonocardiogram showed auricular and mid-diastolic murmurs proving a rheumatic ætiology. In all these 8 cases an Austin Flint murmur had been suspected by others,

but in the 4 where the sound record proved the presence of mitral stenosis the murmur was evidently a true presystolic murmur. Of the other 4 cases with alleged Austin Flint murmur the phonocardiogram showed nothing distinctive in two apart from the early diastolic murmur, and neither auricular nor ventricular moieties of the first heart sound showed anything odd (Fig. 23). In two cases where the aortic regurgitation was free the murmur lasted throughout diastole and was continued into systole (Fig. 24). In these four non-rheumatic cases the systolic murmur commenced at the S line (Fig. 25).

In the 12 cases where the aortic incompetence was considered to be non-luetic, there was no clinical evidence of mitral disease that would have suggested a rheumatic origin for the aortic lesion, but in every instance the phonocardiogram supplied such a proof, demonstrating both auricular and mid-diastolic murmurs. It is true that in two patients, aged 17, and in three, aged 26, 28, and 28 years respectively, a rheumatic aortic incompetence had been presumed because of their age, but the phonocardiographic test gave the proof.

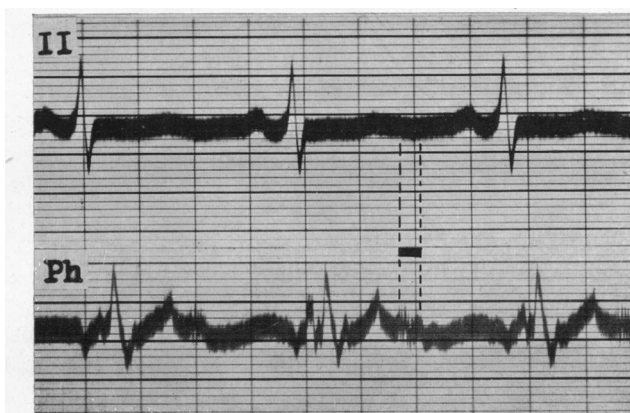


FIG. 23.—Luetic aortic incompetence. A diastolic murmur accompanies the second heart sound. Although three observers told of the presence of an Austin Flint murmur on auscultation the auricular and ventricular moieties of the first heart sound show nothing distinctive.

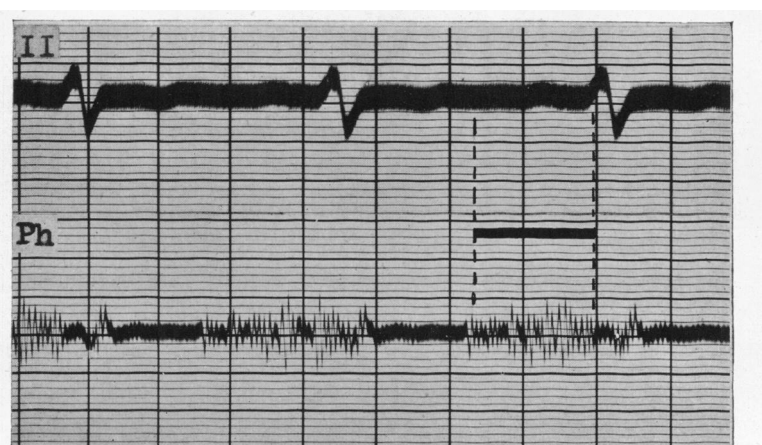


FIG. 24.—Aortic incompetence, luetic in origin and of considerable degree. The diastolic murmur starts at the second heart sound and is continued through the whole of diastole into systole.

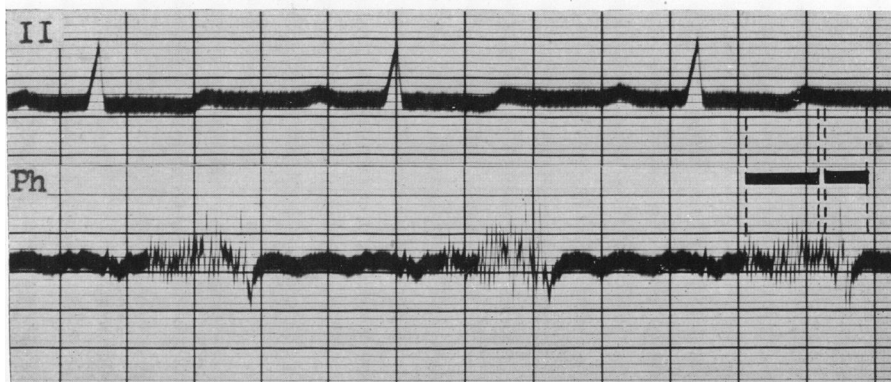


FIG. 25.—Aortic incompetence. The systolic murmur in this case starts in mid-systole some distance after the S line.

The early diastolic murmur was always recorded immediately after the second heart sound, and although variable in its duration, it was usually short and had spent itself mostly when the third heart sound was reached, except when the regurgitation was prominent it lasted throughout diastole to reach auricular systole. In this event the phonocardiogram cannot help to decide the ætiology of aortic incompetence; it is only when the early diastolic murmur has stopped short of auricular systole that an auricular systolic murmur will indicate mitral stenosis, and should it stop short of the third heart sound a mid-diastolic murmur is added as a sign of mitral stenosis.

It is likely that the phonocardiograph, when it comes into routine use, will often reveal an undiscovered aortic incompetence by recording the early diastolic murmur (Fig. 26), although when the test has shown it to be present, careful re-auscultation should discover the murmur.

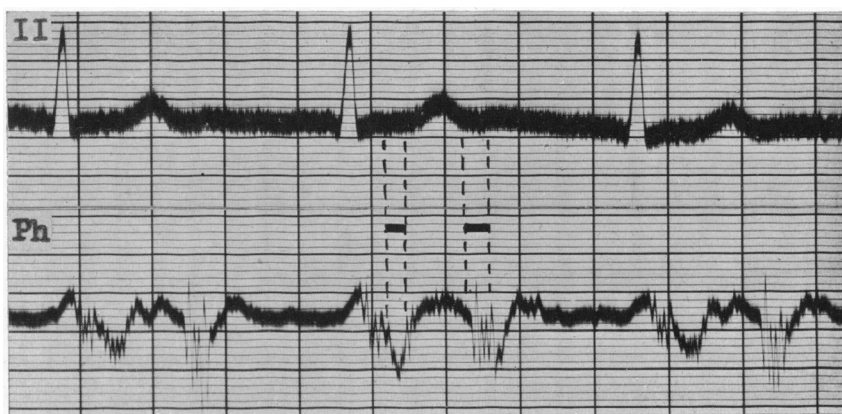


FIG. 26.—Early aortic incompetence. Clinical examination had concluded that a systolic murmur was of the innocent kind, but the phonocardiogram showed an early diastolic murmur. Subsequent examination by direct auscultation easily confirmed the presence of this murmur.

Having noticed the frequency in elderly subjects of a mitral systolic murmur where an aortic systolic murmur is heard best or only heard in the upright posture on direct auscultation and unaccompanied by a thrill, I collected 36 such cases. The cause of the murmur seemed to

be a benign one, and so it proved in two of the patients when examined at necropsy; in one, death had resulted from carcinoma of the bronchus, and in the other, from an unusual form of anæmia. The aortic cusps in both cases showed bars of thickening at their bases by calcareous atheroma which had spread from the aorta on to the aortic aspect of the cusps, producing a sub-clinical stage of aortic stenosis (*aortic valve sclerosis*). A phonocardiogram was recorded in the mitral area in 10 such cases. In 6 the systolic murmur started at the S line as it had done in most patients with aortic stenosis and aortic incompetence, but in the remaining 4 it was postponed until mid-systole (Fig. 27). In 6 cases the murmur stopped short of the second

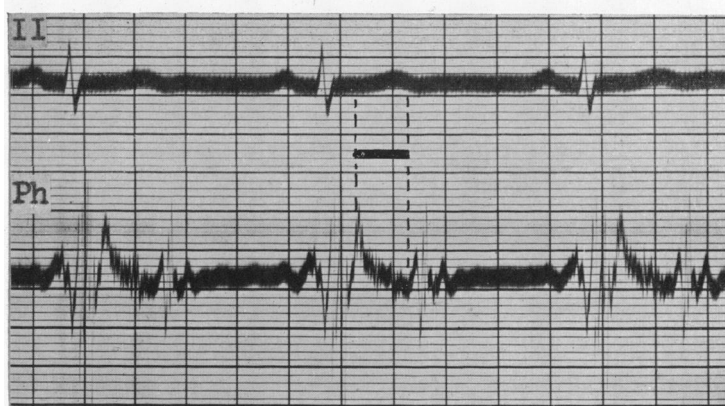


FIG. 27.—Aortic valvular sclerosis. The systolic murmur in this case starts in mid-systole a short distance beyond the S line.

heart sound, and in this respect it differed from the systolic murmur of aortic stenosis and incompetence which reached the second heart sound.

SUMMARY: MURMURS OF AORTIC DISEASE

The phonocardiographic investigation of murmurs heard in the mitral area in *aortic stenosis* has shown that the clinical diagnosis may have to be corrected in two ways. First, the commoner revision applied to the additional diagnosis of aortic incompetence when this has gone unsuspected by auscultation; this added finding was present in the phonocardiogram in every case in this series as it happened, but I have found exceptions since. Secondly, when aortic valvular disease had been regarded as a lone lesion the phonocardiogram twice showed auricular and mid-diastolic murmurs at the apex proving that mitral stenosis was present. Whenever the aortic lesion existed alone the systolic murmur usually started at the S line which marks the commencement of ventricular systole.

In the case of *aortic incompetence* the phonocardiogram frequently demonstrated the presence of mitral stenosis where this had gone unrecognized on clinical and radiological examination. In half the cases where the aortic incompetence was believed to be luetic in origin and showed a murmur that might be described as Austin Flint, the sound tracing showed it was a presystolic murmur of mitral stenosis; in the other half the sound record either showed no change in the auricular or ventricular moieties of the first heart sound, or the early diastolic murmur had lasted throughout diastole into auricular systole.

IV. THE MURMURS OF HYPERTENSION

Patients in whom hypertension was associated with some other form of heart disease were excluded, and only those with hypertension alone were admitted for special study. A phonocardiogram was recorded in 43 cases: in 16 it was used to tell the position of the added sound

that was initiating triple rhythm; in 14 to examine the auricular and ventricular moieties of the first heart sound which showed splitting on auscultation; in the remaining 13 to examine a systolic murmur in the mitral area that was a noticeable auscultatory sign.

THE SYSTOLIC MURMUR

Routine clinical and radiological examination failed to explain with certainty what determined the presence of a systolic murmur in hypertension. The murmur did not disallow a triple heart rhythm because they were sometimes found together in the same patient. The murmur was not a product of associated aortic valvular disease, although in a group of patients, not included in this paper, where aortic incompetence accompanied hypertension, the mitral area was never without a systolic murmur. In hypertensive heart failure a mitral systolic murmur was common although certainly not invariable, but it was noticed that all patients with this murmur showed considerable enlargement of the heart. Thus, among the factors contributing to an apical systolic murmur in hypertension, cardiac enlargement was the most obvious. Further, when a number of patients with a systolic murmur and hypertension, but with only a moderate degree of cardiac enlargement, were examined by the phonocardiograph, mitral stenosis was found to be present although the signs of this had been inconclusive on clinical and radiological examination.

On auscultation the murmur was always distinct, and often it was loud. It never disappeared on deep inspiration, and posture had little effect on it except that often it was heard best in the reclining posture. Being loud the murmur was heard some distance away from the seat of its maximum intensity in the mitral area. There was no selective direction for its propagation, and it was never directed specially towards the aortic area. A regard of the physical qualities of the murmur could not tell it from the systolic murmur of mitral disease, although the absence of a thrill justified the suspicion that it belonged to hypertension, especially if enlargement of the heart was considerable. Radiological examination most times could exclude the presence of added mitral disease and yet a prominent left auricular impression in the barium swallow in the right oblique position often called for care in interpretation. A low and distinctive curve in the left oblique position supported a diagnosis simply of hypertension where a normal left auricle had been displaced backwards by the enlarged left ventricle.

In each of the 13 cases of hypertension with an apical systolic murmur, the phonocardiogram showed the murmur starting in mid-systole, a little way beyond the S line (Fig. 28).

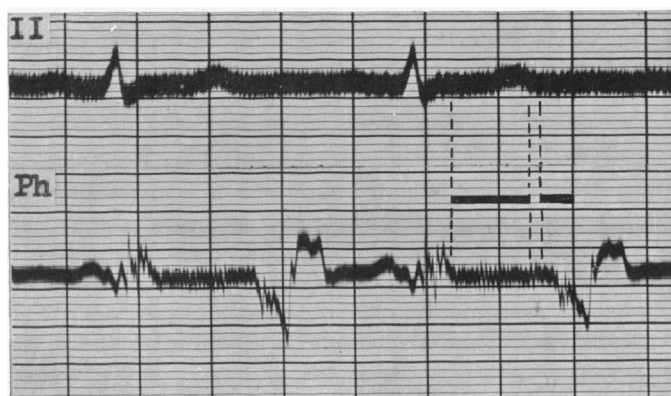


FIG. 28.—Hypertension. The systolic murmur starts in mid-systole a little beyond the S line. A diastolic murmur accompanying the second sound continues in this case up to a prominent third heart sound.

It sometimes lasted up to the second heart sound although occasionally the murmur had spent itself before the end of systole. This was in sharp contrast with the murmur of mitral disease which never once started later than the S line and generally started in front of it and during the P-R period of the electrocardiogram, that is, during auricular systole. Apart from the mid-systolic position of the murmur, the phonocardiogram of hypertension differed from that of the tracing of mitral valvular disease in that there was no mid-diastolic murmur. In the presence of *auricular fibrillation* the same features distinguished the phonocardiogram of mitral disease from that of hypertension, so that in hypertension the systolic murmur started in mid-systole and some way after the S line and there was no mid-diastolic murmur (Fig. 20) whereas the systolic murmur in fibrillation from mitral stenosis started at the S line and a mid-diastolic murmur followed the third heart sound (Fig. 29). The start of the systolic murmur of hypertension in mid-systole also distinguished it from cases of aortic valvular disease where the murmur in most instances started at the S line.

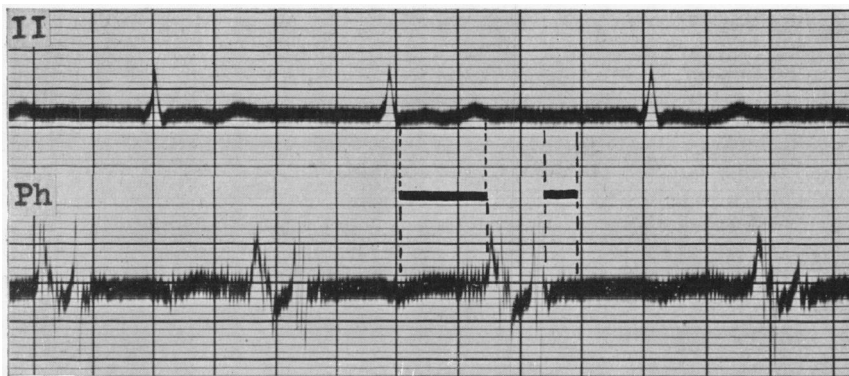


FIG. 29.—Mitral stenosis and auricular fibrillation. The systolic murmur starts at the S line and a diastolic murmur follows the third heart sound.

THE DIASTOLIC MURMUR

Among 43 cases of hypertension there were 12 whose phonocardiogram showed an early diastolic murmur (Fig. 30), although in none could this murmur be elicited by auscultation. The significance of these vibrations of high frequency (as with a murmur) following and contiguous with the second heart sound in the phonocardiogram has been examined, and the

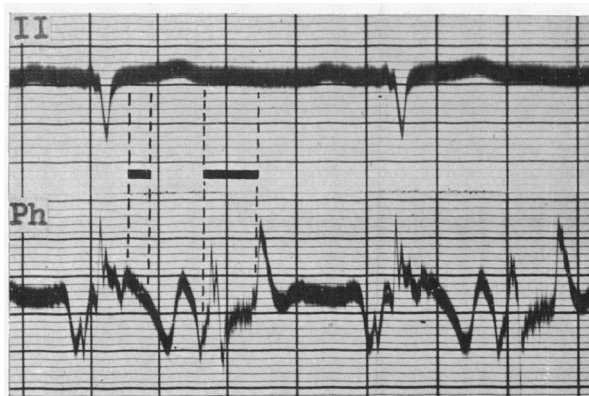


FIG. 30.—Hypertension. A diastolic murmur, which was not heard clinically, accompanies the second heart sound.

possibility considered whether the cause lies with the sudden distension of the aorta in hypertension during early diastole and not with the presence of relative aortic incompetence. In support of a degree of aortic reflux being present were the facts that such a sign was often absent from the sound tracing in cases where the diastolic blood pressure was high and in others where the second aortic sound was very loud, and the presence of the same murmur (or its phonocardiographic pattern) in aortic stenosis where the second sound was not loud and where the diastolic blood pressure was not raised.

A diagnosis of *mitral incompetence* has been applied when a mitral systolic murmur is prominent among the physical signs of hypertension. In 13 patients with hypertension who showed a mitral systolic murmur, it never once coincided with the start of ventricular systole so that it was not produced by incompetence of the mitral valve.

SUMMARY: MURMURS OF HYPERTENSION

The commonest murmur in hypertension is an apical systolic murmur. Cardiac enlargement above all else contributes to its appearance. Should a patient with a raised blood pressure, therefore, show a systolic murmur in the absence of more than moderate left ventricular enlargement, it is likely that the murmur arises from a source other than hypertension. The murmur starts in mid-systole and later than the S line in the phonocardiogram so that its mechanism is not mitral incompetence. An early diastolic murmur from relative aortic incompetence was often recorded in the sound tracing although it could not be heard, but this graphic finding seems to be of secondary importance.

V. THE MURMURS OF CONGENITAL HEART DISEASE

In this variety of murmurs too, phonocardiography has proved useful in confirming a diagnosis when there was doubt and in excluding the innocent kind. The conditions in which the phonocardiogram was most used were patent ductus arteriosus, pulmonary stenosis, auricular septal defect, ventricular septal defect, and coarctation of the aorta.

PATENT DUCTUS ARTERIOSUS

A sound record was taken in 11 cases of undoubted patent ductus arteriosus and a distinctive murmur was found in each. Clinically the murmur was loud and of the machinery kind and was accompanied by a thrill. The third heart sound was never identified on

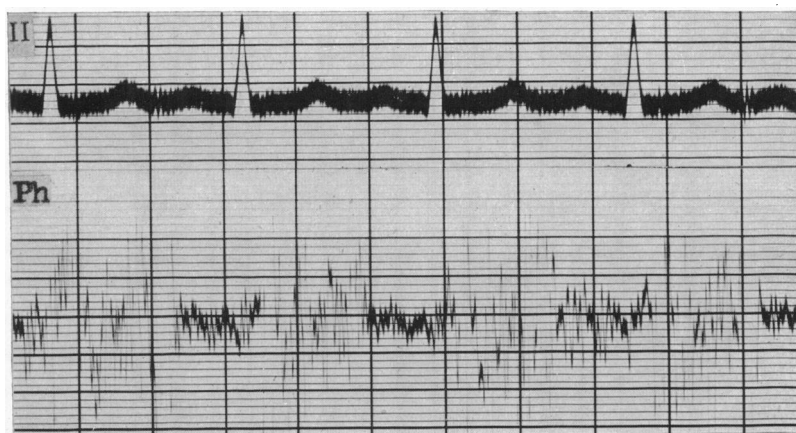


FIG. 31.—Patent ductus arteriosus. The murmur starts at the S line and soon increases, but it declines in mid-systole to increase again in late systole and reaches its height at the second heart sound which it embraces; it also obscures the third heart sound, and occupies the rest of diastole as a moderate murmur.

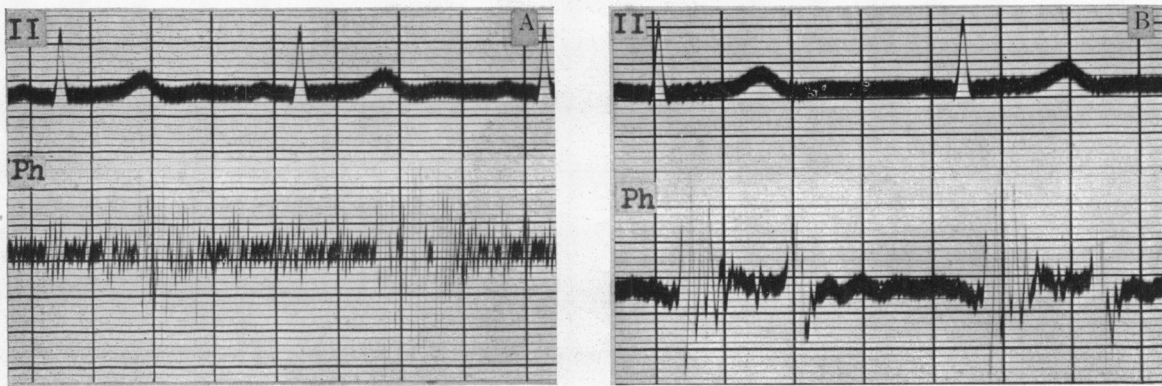


FIG. 32.—Patent ductus arteriosus. The characteristic continuous murmur present in (A) is absent in (B) which was recorded after the duct was ligated.

auscultation amongst the murmurs. Phonocardiographically the murmur was found to be as distinctive as it was clinically, its main characteristic being its continuity throughout systole and diastole. Indeed, when tracing this murmur the galvanometer string is never still (Fig. 31 and 32). The murmur in early ventricular systole starts at the S line, and a little later it becomes more obvious; in mid-systole the murmur wanes; in late systole the murmur increases in intensity at a point corresponding with the summit of the T wave in the electrocardiogram, and at the end of the T wave, where the second heart sound occurs, the murmur is at its height. After thus embracing the second sound it declines until it reaches the position of the third heart sound which it also obscures. Thereafter it continues as a subdued murmur throughout the remainder of diastole and auricular systole. This graphic finding explains the difficulty met with in some cases of patent ductus arteriosus of discovering the second heart sound within the murmur during auscultation.

PULMONARY STENOSIS

A phonocardiogram was recorded in 14 cases; in 11 of these the pulmonary stenosis was considered to be a lone lesion, while in the remaining 3 there was also present a defect of the ventricular septum (Fallot's syndrome). In the first group the murmur in the pulmonary area was loud, and sometimes harsh, and was accompanied by a thrill. In the second group it was less loud and a thrill was absent twice. In both groups the murmur, although louder in the reclining posture, was easily heard in the upright posture. The second heart sound was present as a rule, and no diastolic murmur was heard in these patients.

The murmur in early ventricular systole commenced at the S line; in mid-systole the murmur waned; in late systole it usually increased in intensity at a point coinciding with the beginning of the T wave of the electrocardiogram, until it reached the second heart sound which it embraced, but it ceased before the third heart sound was reached. The relative intensity of the murmur in early and late systole varied so that sometimes it was louder in early systole (Fig. 33), and at other times it was louder in late systole (Fig. 34).

THE INNOCENT PULMONARY SYSTOLIC MURMUR

A systolic murmur in the pulmonary area is a common finding in young subjects, and since so little has been spoken about the differentiation of the innocent murmur from that of pulmonary stenosis, it is a common cause of unwarranted invalidism. Phonocardiography has contributed materially in differential diagnosis because it has confirmed the validity of the clinical signs that identify this innocent murmur.

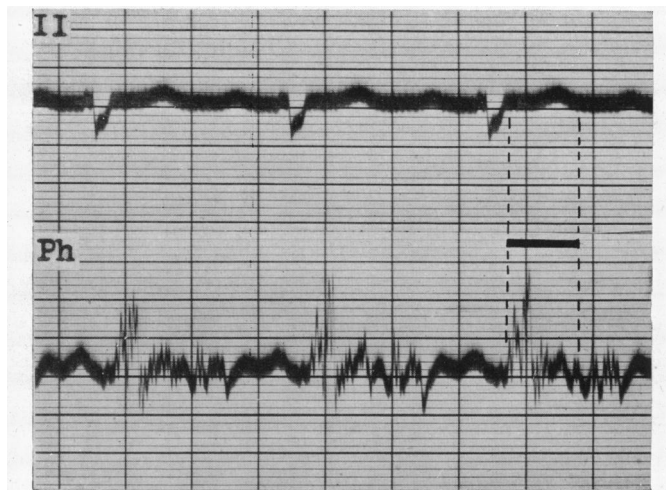


FIG. 33.—Pulmonary stenosis. The systolic murmur starting at the S line is more intense in early ventricular systole; it embraces the second sound, but it is spent before reaching the third heart sound.

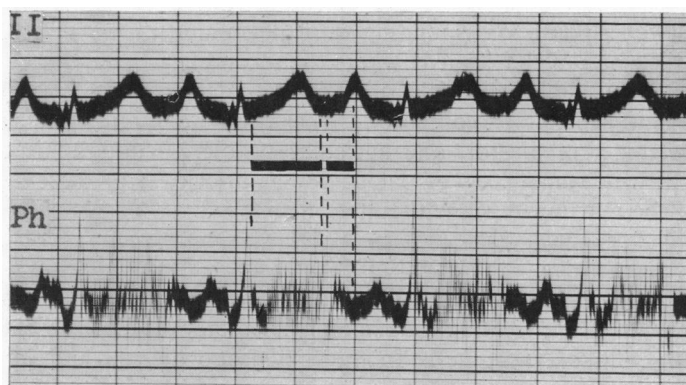


FIG. 34.—Pulmonary stenosis. The systolic murmur which starts at the S line is more intense in late ventricular systole; it overlaps the second sound but disappears before the third heart sound.

The murmur was rough in quality and sometimes it was moderately loud. The effect of posture was a valuable test, for the murmur was much less noticeable in the upright posture; especially when combined with deep inspiration. This innocent murmur was never accompanied by a thrill although the absence of this sign could not be accepted as evidence of the innocence of the murmur since it was often absent when pulmonary stenosis was associated with ventricular septal defect. These clinical signs could not be controlled by reference to the electrocardiogram nor to cardioscopy in both of which negative findings at such tests did not mean that pulmonary stenosis could be excluded, although positive findings were naturally evidence of the organic lesion.

The phonocardiogram will prove a valuable aid to the diagnosis, and in the meantime it has supported the physical signs that have been regarded as the basis of a clinical judgment on the innocence or otherwise of the common systolic murmur in the pulmonary area. The distinctive feature of the sound record was that the murmur started in mid-systole

a little later than the S line and had largely spent itself before reaching the second heart sound (Fig. 35); naturally there were no diastolic murmurs present.

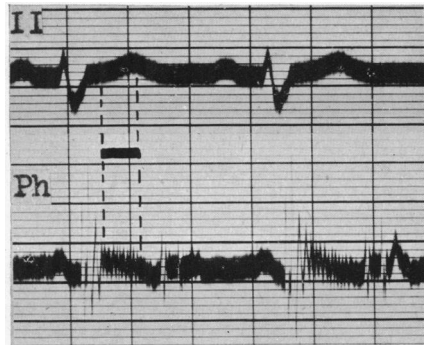


FIG. 35.—The innocent murmur in the pulmonary area. The murmur starts in mid-systole and it has spent itself before reaching the second heart sound.

AURICULAR SEPTAL DEFECT

When a cardiological examination includes an electrocardiogram and cardioscopy, this congenital defect will seldom be missed because of the characteristic signs that these will show. Clinically, however, its recognition continues to remain uncertain. The pulse is usually small, the apex beat is out, and a systolic murmur is seldom absent along a line from the base to the apex, but greatest reliance is placed on finding an early diastolic murmur in the pulmonary and mitral areas which is probably not heard to the right of the mid-line as is the murmur of aortic incompetence. When such a murmur is present—and it has a high incidence—moderate or greater dilatation of the pulmonary artery can be predicted on radiological examination for it is the outcome of relative pulmonary incompetence from dilatation of the arterial ring. If a clear third heart sound is heard along with this murmur the diagnosis of auricular septal defect is more certain.

The auscultatory findings are shown characteristically in the phonocardiogram (Fig. 36) with the systolic murmur starting at the S line, the early diastolic murmur following immediately after the second heart sound, and a clear third heart sound beyond. This phonocardiographic finding is in contrast with the early diastolic murmur of rheumatic aortic incompetence when the third heart sound, if present, is often followed by the mid-diastolic murmur of mitral

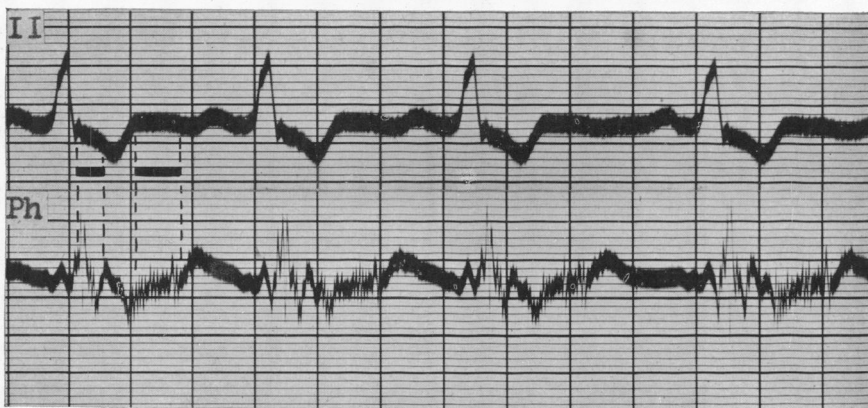


FIG. 36.—Auricular septal defect. The systolic murmur starts at the S line and the diastolic murmur of pulmonary incompetence accompanies the second heart sound and lasts as far as the prominent third heart sound.

stenosis. Occasionally, however, auricular septal defect is present alongside mitral stenosis (Lutembacher's syndrome) where in addition to the early diastolic murmur of pulmonary incompetence there are the auricular and mid-diastolic murmurs of mitral stenosis (Fig. 37).

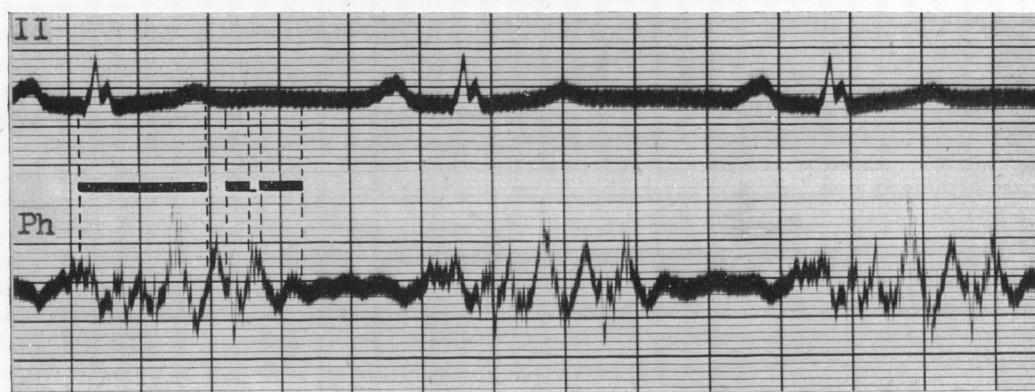


FIG. 37.—Auricular septal defect and mitral stenosis (Lutembacher's syndrome). The systolic murmur of mitral stenosis starts during auricular systole and a mid-diastolic murmur follows the third heart sound. The diastolic murmur following the second heart sound is caused by pulmonary incompetence.

VENTRICULAR SEPTAL DEFECT

The murmur of ventricular septal defect has already been described in the section dealing with the innocent parasternal murmur. It is loud and almost invariably accompanied by a thrill. Apart from the possible association of an abnormal electrocardiogram and radiogram, the phonocardiogram is characteristic for it shows the murmur starting at the S line and, therefore, earlier than the innocent murmur; it also lasts longer (Fig. 8 and 9 in previous paper).

COARCTATION OF THE AORTA

Hardly any of the orthodox areas for auscultation of the heart are without a systolic murmur in a patient with coarctation of the aorta, although it is seldom loud anywhere. Like the murmur over the back, the murmur over the front of the chest usually arises from the hypertrophied arteries of the collateral circulation. Rarely, the murmur has its source in the heart from the greatly enlarged left ventricle, and especially in the presence of aortic incompetence.

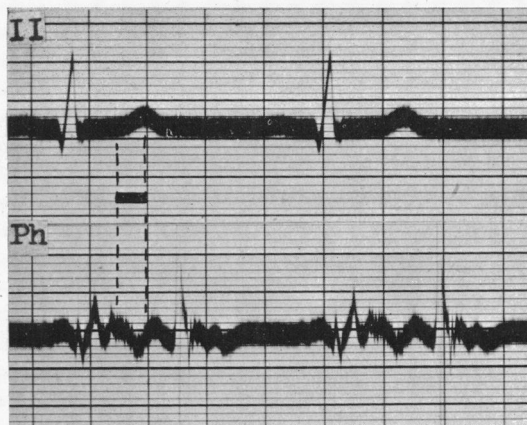


FIG. 38.—Coarctation of the aorta. The systolic murmur starts in late systole and some distance after the S line.

In the second circumstance, the phonocardiogram shows the murmur commencing in mid-systole, but if it arises in the hypertrophied arteries it is even later in systole (Fig. 38). The incidence of relative aortic incompetence, producing an early diastolic murmur in the sound record, is commoner in coarctation hypertension than in other forms of hypertension.

SUMMARY: MURMURS OF CONGENITAL HEART DISEASE

The murmur of *patent ductus arteriosus* is a continuous one lasting throughout systole and diastole, with intensification in early diastole where it covers the second heart sound and proceeds to obscure the third heart sound as well.

The murmur of *pulmonary stenosis* starts at the S line and lasts till it reaches the second heart sound which it embraces, but it ends before reaching the third heart sound. The murmur appears earlier in systole than the innocent pulmonary murmur, commencing as it does at the S line of the phonocardiogram.

An early diastolic murmur from pulmonary incompetence followed by the third heart sound are the characteristic phonocardiographic findings in *auricular septal defect*. When mitral stenosis is added to the congenital anomaly (Lutembacher's syndrome) there are added auricular and mid-diastolic murmurs.

The systolic murmur of *ventricular septal defect* commences at the S line and thus differs from the innocent parasternal murmur which starts in mid-systole; it also lasts longer.

The common systolic murmur in *coarctation* is the one heard over the hypertrophied arteries of the collateral circulation so that it occurs late in systole. Less frequently the murmur comes from the greatly enlarged heart and aortic incompetence is then usually present, so that the murmur is earlier in systole.

VI. THE MURMUR OF HEART BLOCK

A systolic murmur in the mitral area in heart block is only found when the heart is greatly enlarged. It is a rough murmur and it may be loud. Posture is without much effect on its intensity although it is sometimes better heard when the subject inclines to the left. A thrill is never present unless there is mitral or aortic valvular disease as well.

In seven cases of complete heart block with a systolic murmur in the mitral area, the phonocardiogram showed the murmur starting in mid-systole (Fig. 39). Graphically it was

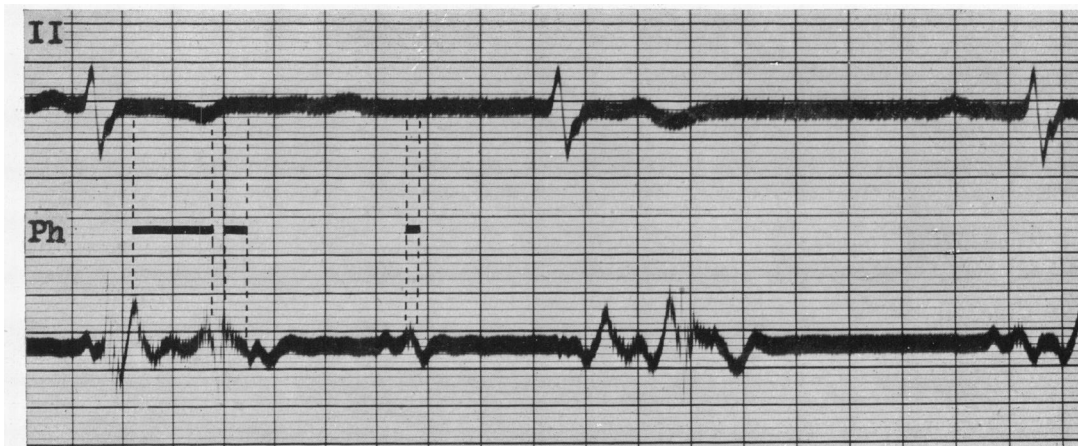


FIG. 39.—Complete heart block. The systolic murmur starts in mid-systole, and a diastolic murmur follows the second heart sound. The murmurs are similar to those found in hypertension associated with much cardiac enlargement. The natural auricular diastolic murmur is also recorded.

similar to the murmur of hypertension except that the tracing did not as often show an early diastolic murmur which was sometimes present in the record from a case of hypertension. Although hypertension appeared along with complete heart block in three cases, the systolic murmur was in the same situation in the other four without hypertension.

SUMMARY: MURMURS OF HEART BLOCK

The systolic murmur of complete heart block has been shown by the phonocardiogram to start in mid-systole. Thus, the mechanism of the murmur in heart block as well as of the one in hypertension appears to be connected with the muscular contraction of a much enlarged heart; the start in mid-systole excludes a valvular origin for the murmur.

VII. THE MURMUR OF ANÆMIA

Although an obvious murmur is heard in the majority of patients with a significant anæmia, it is sometimes absent even when the anæmia is severe. Its presence does not depend on the size of the heart. The murmur as a rule is widely distributed and may be heard in the aortic area as well as in the pulmonary and mitral areas; when present in more than one area it is usually loudest in the pulmonary. The murmur varies in intensity so that it may sound faint or rough, and it is better heard in the reclining than the upright posture. Although diastolic murmurs have been described in anæmia, I have never heard them.

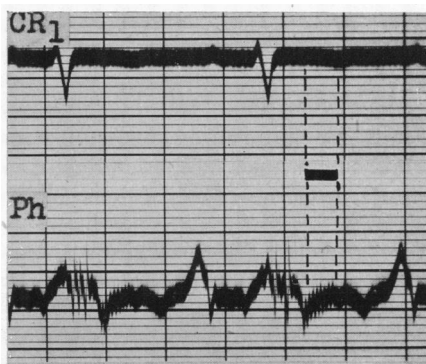


FIG. 40.—Anæmia. The systolic murmur starts in mid-systole some way after the S line. A prominent third heart sound follows the second.

Whenever the phonocardiogram was recorded it showed the murmur starting in mid-systole (Fig. 40). An obvious third heart sound was seen whenever the heart was enlarged as the result of the anæmia.

SUMMARY: MURMURS OF ANÆMIA

The only murmur to show in the phonocardiogram from patients with anæmia was the one in mid-systole. A diastolic murmur was not once recorded.

GENERAL SUMMARY AND CONCLUSIONS

The heart murmurs in 500 healthy subjects and patients with heart disease were specially examined, both by clinical auscultation and by phonocardiography. The object of the investigation was to determine the physical characteristics of murmurs that would make their clinical recognition both easier and more certain. Ancillary methods of examination including electrocardiography were used whenever necessary, and cardioscopy was never omitted. Necropsy was sometimes available.

Foremost amongst the findings of the investigation was the clinical identification of the *innocent mitral systolic murmurs* which continue to cause widespread unwarranted invalidism because of their common appearance; on this account their recognition is a matter of concern unequalled by any other in clinical cardiology. The situation and distribution of these murmurs and the effects upon them of a change in posture and deep breathing make it possible to tell them from the murmurs of organic heart disease. The phonocardiograph confirmed this clinical classification and located the murmurs either in mid-systole or late systole; it also showed the absence in such cases of auricular systolic and diastolic murmurs. In patients with *mitral stenosis* the phonocardiograph showed that the murmur which presented clinically as a systolic murmur usually started during the P-R period of the electrocardiogram, that is during auricular systole, as did the presystolic murmur. Even in the few exceptions where the murmur was later and coincided with the start of ventricular systole, the term "mitral incompetence" would have been incomplete as in each there was a mid-diastolic murmur giving proof of mitral stenosis. The common incidence of a mid-diastolic murmur immediately succeeding the third heart sound in mitral disease, for it was found in each of 74 cases, stimulates the clinical search for this murmur in patients suspected of the condition. Should future investigation show that this is an invariable graphic finding in mitral disease it will prove to be a physical sign of inestimable value.

In *aortic valvular disease* the systolic murmur, which was an unfailing sign in the mitral area, was seen phonocardiographically to start synchronously with the start or early part of ventricular systole. The test showed the common incidence in aortic stenosis of the early diastolic murmur of aortic incompetence although this sign had not yielded to clinical auscultation. The phonocardiograph has often demonstrated an early diastolic murmur when aortic incompetence is unsuspected by casual or even careful clinical examination. On this account too the test has proved of great value.

The mitral systolic murmur in *hypertension*, making its appearance whenever the heart is greatly enlarged, was recorded in mid-systole and a little time after the ventricle had commenced to contract; such a finding opposes the assumption that this murmur is the outcome of mitral incompetence. Doubtless it is the result of muscular contraction and the same murmur was found when the heart was much enlarged in *complete heart block*. In both conditions an early diastolic murmur of relative aortic incompetence, resulting from dilatation of the aortic ring, was a fairly common event, and when it was present it served to emphasize the presence of considerable left ventricular enlargement.

The phonocardiogram in *congenital heart disease* helped to tell the innocent parasternal murmur from that of ventricular septal defect, and the innocent pulmonary systolic murmur from that of pulmonary stenosis. The test demonstrated the continuity of the murmur of patent ductus arteriosus with its accentuation in early diastole. An early diastolic murmur from pulmonary incompetence, leading up to an obvious third heart sound, was never absent in the sound tracing from cases of auricular septal defect; when mitral stenosis was added to the congenital lesion (Lutembacher's syndrome) so were auricular systolic and mid-diastolic murmurs to the phonocardiogram. The murmur of coarctation of the aorta was written in late systole. In *anæmia* the murmur started in mid-systole and a diastolic murmur was not once recorded.

This phonocardiographic study of heart murmurs has shown that the quality and intensity of murmurs matter far less than their place in the cardiac cycle and in relation to the heart sounds. Such a finding emphasizes the need for self-catechism during clinical auscultation when precise answers should be sought to six set questions. The questions concern the character of the first heart sound and similarly of the second heart sound, the presence of more than two sounds, and the presence of murmurs connected with the first heart sound

(presystolic and systolic), with the second heart sound (late systolic and early diastolic), and with the third heart sound (mid-diastolic). When such simple auscultatory procedure has become custom, cardiological diagnosis will have gained immeasurably in accuracy.

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